3. Election Lab

A Computer Board Game Where STEM Meets Civics

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Abstract: *Election Lab* combines math and civics in a game-based learning platform for middle and high school students. It opens the eyes of learners to the hidden but strategic role of STEM professionals in increasingly data-driven presidential campaigns. The games present learners with 1 of several actual election scenarios from recent history—from landslides to very tight races. The game design is a hybrid of a board game and computer, leveraging advantages of both formats. The physical board game uses large, high-resolution electoral maps and manipulatives; provides a hands-on experience; and increases accessibility for English language learners and others who may not benefit from traditional presentations of math concepts. The accompanying computer speeds up play with an interactive display that updates after each state battle; automatically calculates the electoral vote totals for each candidate; and most important, captures gameplay data for later statistical analysis and discussion. The result is a novel informal learning program that uses math to understand strategies used in elections, and that uses data generated from gameplay to allow learners to think like statisticians. Elections come alive when they are played, driving history learning. Finally, experiencing an election from the point of view of a campaign strategist and understanding the convoluted mechanics of the Electoral College firsthand will engage future voters, especially for populations that have historically low voter participation.

Introduction

Participatory democracy depends upon an informed, engaged, and scientifically literate electorate. This cross-disciplinary learning game uses STEM to explore a civic issue of great importance: how we choose the next president. Unfortunately, many Americans understand this process poorly, and civic engagement remains a challenge.

The Electoral College

Our system of selecting the president of the United States is second only to choosing the next Dalai Lama for its oddity ("Reincarnation," The Dalai Lama, 2019). The international press is justifiably baffled (*Japan Times* [Drew], 2016; *Le Monde*, 2016; *Süddeutsche Zeitung*, 2016; *The Economist*, 2012;). But our familiarity with the system has robbed it of its strangeness: When it is explained to students, much of the instruction time is spent simply explaining the mechanics (Herczog, Kidwell, & Croddy, 2011). Yet every four years, despite the best efforts at civic education, the search term "Electoral College" spikes each day after Election Day (Figure 1).

Keeping up with current events is not always helpful, either. Increased fragmentation of news sources has offered more choice when consuming news while increasing the hazard of being less informed (Cassino & Woolley, 2012)—at the same time boosting a false sense of confidence in being well informed (NORC, 2016). In an election year, journalists often report from so-called "swing states" without explaining why these states are different, or why they are important. Political pundits are even worse: Their predictions turn out to be no better than chance (Silver, 2012).

The reason the Electoral College is both uninteresting and difficult to understand, the authors believe, is that it takes mathematics to understand the insights. But mathematics is most often taught in another classroom, and the mathematics that is taught there has been (until very recently) largely devoted to computation—not mathematical thinking. The good news is that these circumstances are changing for the better. Data literacy has been identified as a critical skill for 21st-century workers, and data literacy has been endorsed by the American Library Association (2013) as well as the National Council for the Social Studies (NCSS; 2018). But the challenge is implementation: Social studies and history teachers are not typically required to take mathematics beyond their freshman year (CSULB, 2019; Columbia University Teachers College, 2019), and data literacy is a relatively new course in graduate education programs for teacher certification (GVSU, 2019).

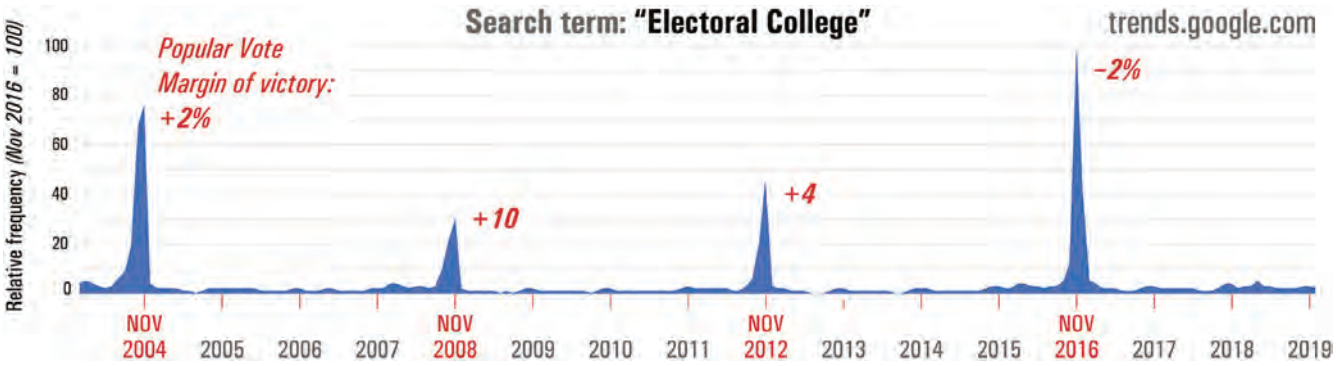

Figure 1. Americans still struggle to understand the Electoral College. Results from Google Trends for the search term "Electoral College" are plotted from 2004 to 2019. Notice the periodicity that peaks in November every election year. The height of the peak is inversely proportional to the margin of victory by popular vote: The closer the margin, the greater the number of searches.

American Achievement Gap in Mathematics

Global economic competition has placed even greater pressure on our education system, but American student performance on the National Assessment of Educational Progress for eighth-grade math has not improved since 2007 (NAEP, 2017). When compared to other nations, the United States has consistently ranked below the OECD mean in math (PISA, 2018). Student understanding of math concepts, especially where and how to apply them appropriately to novel situations, has been particularly difficult to teach. As more data migrate online, both in quality and in volume, data literacy has become an increasingly crucial skill in science, industry, and government.

Mock Elections: An Imperfect Means to Improve Civic Engagement and Voter Participation

In election years, public schools across the country conduct mock elections during classroom time, with students voting for the candidates on a mock ballot, in an effort to instill in them the virtues of participatory democracy (nationalmockelection.org, 2014). While the goal is laudable, in reality students often go through the motions of voting without developing a firm understanding of our electoral process.

Methods

Election Lab was developed as a cross-disciplinary learning-game platform that combines STEM and civics: It uses math to elucidate a complex yet very important electoral process, the election of our president. It addresses an educational need for more mathematical rigor and data literacy in social science teaching for K-12 (Cobb & Moore, 1997; Steen, 1999; Vahey et al., 2010).

To improve future voter engagement, *Election Lab* flips the traditional perspective from *voter* to *campaigner*, allowing players to see the electoral map as the campaigns see it. They are given an authentic role to play (D. A. Kolb, 2014; Y. A. Kolb & D. A. Kolb, 2009; Shaffer, 2005): Create and implement a strategy that places their limited campaign resources on enough states to win the presidency. Moreover, this strategy is tested, head-to-head, against a competing campaign. To ensure that this learning game can fit within a classroom period, playing time was designed to last 25 minutes. As a computer hybrid game, *Election Lab* removes the biggest source of friction for traditional strategy board games: cumbersome setup, complicated mechanics, and tedious bookkeeping.

The Setting

With just a few weeks before the presidential election, players take on the role of campaign strategists. Most states are already firmly in one camp or the other, leaving a handful of states still in play: *the swing states*. Players must win enough of these swing states and their electoral votes for victory in the election.

The Physical Game Board

Eight election years were chosen, to provide a range of electoral scenarios, from closely contested to landslide (1860, 1876, 1960, 1988, 2000, 2012, 2016, and 2020). For each election year, the electoral map reflects the actual polling numbers for each state (Figure 2). Red states are firmly Republican, blue states are firmly Democratic; in contrast, white states can be won by either side. Where robust polling data was not available, the final election results were used: States won by >5% by either side are colored for that campaign. State results that were close (within ~5%) are colored white. Players must decide how to deploy their *limited campaign resources*, *represented by game pieces*, to win the states still in play.

Figure 2. The game board setup with partition (left) and ready to play (right).

Furthermore, these deployments are done in secret, hidden from the other campaign by a removable partition. Once both campaigns are finished with their setup, the partition is removed, and the campaigns battle, state by state, to determine the winner. The game pieces themselves translate into the number of dice each team can roll. More pieces mean more chances at winning, but having more dice to roll than the other team does not guarantee victory. *Dice represent imperfect polling in any election* and the difference between projected and actual votes.

Companion Computer to Display the Interactive Map

Players share a Chromebook or other device that is open to a map that tallies the electoral votes after each state is won. This web-based map also serves an important external check to keep track of which states still need to be played, because pilot testing has shown that teams occasionally forget to remove pieces from a state after it is won or lost. As groups use the web-based map, the results are recorded to a group file that the instructors can display. These group data are a starting point for the discussion that follows.

Results

From 2016 to 2018, *Election Lab* has been played by students (N = 517), teachers (N = 62), administrators (N = 21), and parents (N = 40). Feedback has been overwhelmingly positive: students rated the game highly; social studies teachers liked the ability of the game to bring history alive; math teachers liked using the gameplay data, bringing statistics and probability alive. Administrators recognized the civic value of engaging future voters. And parents who played the game with their children at home found a way to connect with them around math and civics, learning about both in the process.

Pilot testing with 25 middle school students in 2016 revealed the length of the game was: *too short* (8%), *too long* (20%), and *just right* (72%); 88% would play the game again. Early feedback from players was crucial in developing a fast-paced game that was easy to play but hard to master. Rules were adjusted to account for edge cases. A second round of testing with a larger group of eighth-grade students (n = 208) dramatically improved ratings for how much fun players had: 43% rated the game *very good* or *excellent* in pilot testing, while 82% rated the game *very good* or *excellent* in the second round.

Gameplay Data

When students play the election games, they generate two kinds of data that are available for group analysis and discussion:

1. The initial positions staked out by each campaign;
2. The final results for each swing state.

The initial positions reveal the strategic choices made by the teams. Players must distribute their resources (24 pieces) from 10 to 20 swing states, depending on the election year. The states themselves are worth electoral votes ranging from 3 to 47. A first-order optimal strategy would be to allocate more game pieces on the more valuable states. Indeed, this is what most teams do:

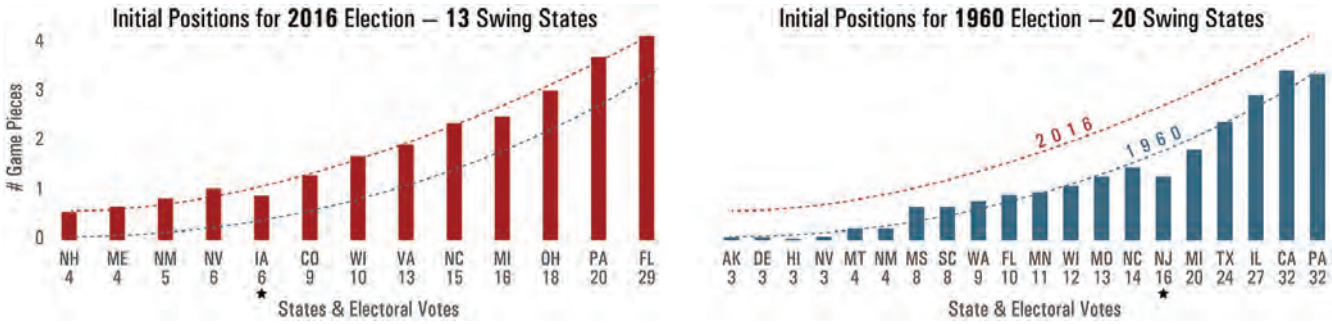

Figure 3. Data of initial positions for 2016 and 1960.

Players tend to place more pieces on more valuable states (see Figure 3). But differences in the strategies between 2016 (13 swing states) and 1960 (20 swing states) emerge upon closer inspection. Because the same number of game pieces are distributed across more swing states in 1960, students must spread their resources more thinly. Most players for the 1960 election abandoned several states, while only half the players did so for 2016. Iowa (IA) and New Jersey (NJ) are marked with a star because players placed fewer resources than one would expect based on the trend.

In 2016, Nevada (NV) has just as many electoral votes as Iowa, but it received more game pieces, probably because it is larger (and more easily seen on the map). Likewise, in 1960, New Jersey is underrepresented with game pieces, probably because this small but valuable state is easy to overlook.

More sophisticated strategies begin to evolve as students gain experience against more opponents and in different election years. Indeed, these results led to creation of the exercises shown in Figure 5: A gradually weighted strategy can be beaten by a more aggressively weighted strategy. History provides some evidence that this evolved strategy was successfully used: In 1960, Nixon visited all 50 states during the campaign, while Kennedy focused on important swing states. And in 2016, Trump visited states in the Rust Belt he needed for victory, while Clinton, confident that the "blue wall" would hold, spent precious time visiting states that were only marginally in play.

Statistics Analysis

Students struggle to master statistics, in part because they do not have a personal connection with the data (Konold & Higgins 2003), or because they struggle to place individual results in context. Language barriers create additional challenges when statistical scenarios are commonly presented as word problems. In stark contrast, *Election Lab*, by virtue of its computer-board game hybrid design, uses gameplay data as raw material for a mini-statistics lab.

Data display/dot plots/histograms. Students make the transition from the game board to data in several small steps (see Figure 4). The pieces themselves are round and amenable to representation as dot plots. Transitioning to a histogram is a natural progression, because the game interface encourages them to think in these terms:

1. The physical game is shown with red pieces placed on the 1876 map.
2. Then the on-screen representation of the game is shown, with the red pieces.
3. Users can set the number of pieces with a User Interface that has (+) and (−) buttons for each state. The number of pieces that are placed is depicted as a series of red dots, also known as a dot plot. It is a building block for further ways of displaying and analyzing data.

4. Removing the dots, and we have a bar chart of the values, also known as a histogram.

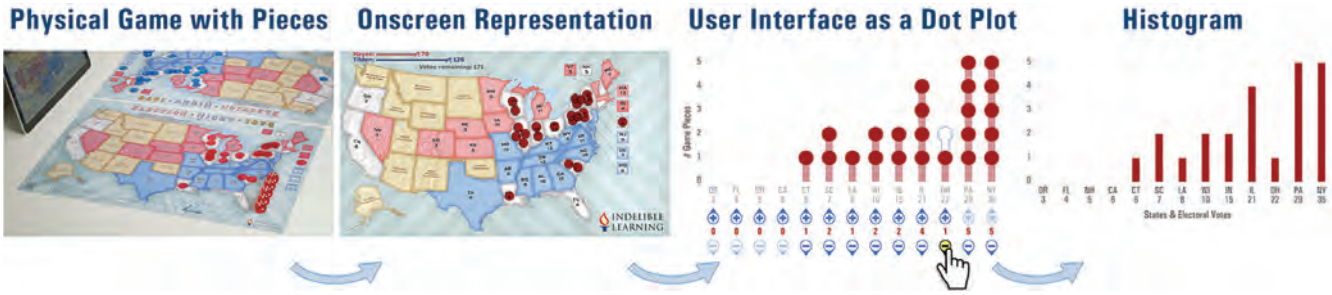

Figure 4. Migrating students from physical placement of pieces on a map to data plots.

Once at the histogram level, players start seeing the game from this dashboard indicator. They can compare other games from other players. Each is a plot of opening strategies, as shown in Figure 5.

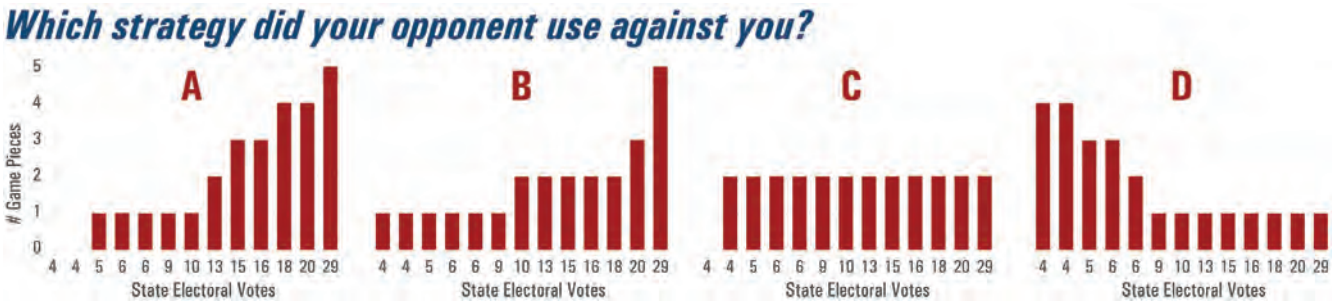

Figure 5. A sample of the postgame analysis.

Players who are accustomed to seeing the initial positions displayed as a histogram can then learn to recognize patterns of the different strategies. In Figure 5, states are plotted from least to greatest electoral votes. Strategy *A* is heavily weighted toward the high-value states and is forced to abandon the two low-value states. *B* is also weighted, but it ensures every state has at least one piece. *C* is a flat strategy. *D* is a nonsensical strategy that wastes resources on low-value states.

Each game played is a discrete event felt palpably by the students who participated in it. A losing strategy may have been ineffective because the opponent was better at deploying resources. Or it may have been due to bad luck. Knowing which explanation is more likely requires understanding *expected value*, shown in Figure 6.

Figure 6. Using game strategies and simulated games to explore expected value.

In this exercise, students are given the opportunity to peek at the opponent's strategy (in this case, Blue's strategy, played by the computer). They are challenged with setting a strategy that would be expected to beat it. Then the computer runs 1 million simulated games and tallies the results. This example is from the 2016 election, in which Blue has placed most of his pieces on the three biggest swing states, Ohio, Pennsylvania, and Florida. The player can beat this strategy by placing individual pieces on the states abandoned by Blue, and abandoning Ohio. The expected value for Red's strategy is 89.97, exceeding the 79 electoral votes needed to win.

Civics Analysis

By playing the game, students gain first-hand experience of the strategic challenges that the historical campaigns faced. Since the game works within the rules of the Electoral College, it closely reflects the mechanism by which campaigns win.

- Players for Governor Romney in 2012 quickly realize how important Florida and Ohio were to his campaign.
- After playing the election of 1860, players can easily determine whether Southern and Northern Democrats could have beaten Lincoln had they united under a single nominee.
- In 1960, the electoral map was unusually broad: 20 swing states were in play. Despite Nixon's built-in advantage at the start of the game, Kennedy still has many paths to victory. In the actual election, Kennedy deployed a shrewd swing-state strategy that was superior to Nixon's.

This first-hand experience is an essential tool of engagement. Students are genuinely curious about the candidates and the actual outcomes once they have played these roles themselves.

- From the game map, they know which states were up for grabs.
- When shown the resulting electoral map from the actual election, they immediately make comparisons to the final state of the map for their game.
- By seeing the electoral map at the start of the game, and playing to win, they know which states were important.

Playing the games creates a sense of surprise. As the results from all the games played in the class are compared, they get a sense of how likely or unlikely the historical outcome was.

- In 1876, 1960, 2000, and 2016, the historical outcomes were unexpected.
- And in the game, Tilden, Nixon, Gore, and Clinton start with varying leads over their opponents, with slight to great probabilities of winning.
- All four candidates lost in the actual elections.

Discussion of *which* states were won by successful campaigns easily turns to *how*.

- Which messages resonated with Southern voters in 1960?
- How could Kennedy diffuse Nixon's obvious advantage in foreign policy experience? Did Dukakis have the same challenge with Bush in 1988?
- In 1860, how circumspect did Lincoln need to be about abolishing slavery during his campaign?
- Would it have mattered for the election, or was he thinking ahead about holding the fracturing nation together?

Discussion

This project applies statistics and probability content standards to develop a cross-disciplinary, data-driven course on civics. The program uses game-based learning to provide immersive simulations of actual election scenarios and invites students to build conceptual models of these elections, and then to test them against other teams in head-to-head contests (just as in real elections). By using statistics, probability, and mathematical practices in a game-based learning environment, students can engage in constructive struggle to master these skills in an environment that rewards persistence and is forgiving of failure. Games also allow wider access to students who do not consider themselves good at math, or who may struggle with language or text presentations of math problems. Data generated from the games themselves allow quick and easy comparisons of many trials, visually displayed, and are amenable to statistical analysis and group discussion. Moreover, students are genuinely curious about an election year they have just played, providing the perfect setting for a social sciences teacher to provide historical context. Overall, it is a positive, powerful first experience with elections for future voters.

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